Design Computer Application for Memory Rehabilitation Using the Method of Loci

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ABSTRACT

Memory rehabilitation involves the processes of memory assessment and training. Nowadays, with the help of technology, customized applications can be designed, but they require an efficient prior design. This paper presents the design of an application for memory rehabilitation using the method of Loci. In the development of the

methodology three stages are included, where the first phase contemplates the design of breathing exercises that relax the patient and promote the use of imagination. In the second stage, two cognitive exercise activities are designed, one with element matching and the other with the assignment of elements in four places in a home. The last stage is for evaluation and measures the user's performance, using response times and scores obtained as metrics. The application is designed through screens at different levels, orienting the system to be implemented on a computer, but without limiting the implementation to other types of devices. The results show the final design sketches, evidencing the characteristics of the proposed application. Finally, the proposed design is analyzed concerning recent literature, concluding with its advantages and disadvantages.

Keywords: Memory Rehabilitation, Method of Loci, Application Design.

INTRODUCTION

In ancient times it was believed that an optimal state of health in the human being meant the absence of disease (Wu and Deng, 2019). This is why people performed extensive physical exercise routines, had a balanced diet, and were clearly concerned with the physiological aspects of their bodies. At present, it is known that there must be a correct relationship between the body and the mind, as well as a good development in society. (Patel *et al.*, 2018). That is why the WHO now recommends that mental health be given equal importance and thus be able to have a better quality of life (Arango *et al.*, 2018; Yao, Chen and Xu, 2020).

Like a routine physical exam, determining the status of a person's cognitive functions requires evaluation of each of them. Since mental illnesses are very common, several methods have been developed to identify disorders of mood, anxiety, eating, stress, among the main (Peng *et al.*, 2017; Varela-Aldás, Buele, Lorente, *et al.*, 2021). It can also be evaluated if there is a decrease in the main cognitive domains such as memory and learning, language, or executive functioning. In this way, identify changes in the patient's behavior and establish an accurate diagnosis that could include drugs or only the execution of therapy by a specialist. (Soveri *et al.*, 2017).

Memory is a cognitive function that requires further analysis to ensure the correct performance. It receives data and stores it; and when they are required, it restores them and shows them so that they can be used as needed. Possessing functional learning allows the person to use the information to solve a complex situation, repeat something they have just seen or acquire new knowledge (Sala and Gobet, 2017). Since the mechanical memorization that was practiced before does not allow a correct understanding and improvement of these capacities.

For this reason, it is necessary to change traditional habits and establish new forms of training and learning, such as reading comprehension. More specialized methods have also been developed such as the PQRST (Preview, Question, Read, State, and

Test) or the SQ4R (Scan, Question, Reading, Reciting, Remembering, and Revision) (Başar and Gürbüz, 2017). However, there are methods that have been used since ancient times due to their ease and high efficiency, such as Loci. The origin dates back to ancient Greece and is attributed to the Greek poet Simónides of Ceos; being the etymological meaning in Latin "place". It is defined as a set of techniques that contribute to the memory of elements associated with the place where they are located (Verhaeghen and Marcoen, 1996).

This technique uses spatial memory to expand the person's ability to remember objects in general. The difference with others is that it does not increase spontaneous memorization, i.e. memories not are evoked by themselves. Rather, it is used in a timely manner when it is necessary to accumulate a large amount of information, without the need to write it down. In addition, it links breathing exercises and imagination that allow having a true experience of relaxation and rehabilitation at the same time (Lea, 1975).

Automating cognitive evaluation and rehabilitation tools that were previously carried out manually is a currently well-received research topic. As can be seen in (Wang *et al.*, 2017) students' reading ability is evaluated through e-books integrating the SQ4R and Student Team Achievement Division (STAD) tools. The results prove that the use of technological tools provides greater motivation to students. On the other hand, in (Varela-Aldás, Buele, Pérez, *et al.*, 2021) the Face-Name Associative Memory Exam (FNAME) test is presented in a computer application, quantifying the number of hits when matching a face with the corresponding name, using associative memory. In this way, the exact response times of the participants can be obtained by replacing conventional processes.

As has been shown in the literature presented, mental health should not be neglected and it is important to properly use those tools that allow improving cognitive domains. Memory training brings benefits for humans in their processes of acquiring new knowledge. Therefore, it is necessary to be able to automate the tools and methods of evaluation and cognitive rehabilitation, which is proposed to design in this research.

This document consists of four sections, including the introduction in section 1. The methodology and results are shown in section 2 and section 3 respectively. Finally, in section 4 the conclusions and discussion of the work are described.

METHODOLOGY

This research aims to design a computer application for memory training. Among the existing techniques that improve this cognitive function is the method of Loci, which helps the patient to link elements that he wishes to remember with their location. In this way, the patient's information retention capacity is increased. Figure 1 contains the stages to be designed, beginning with breathing exercises to facilitate the relationship, as an activity before imagination. In the training stage, 2 exercises are

designed, pairing of elements and location of elements. Finally, the independent evaluation of each training exercise allows obtaining the results of the process.

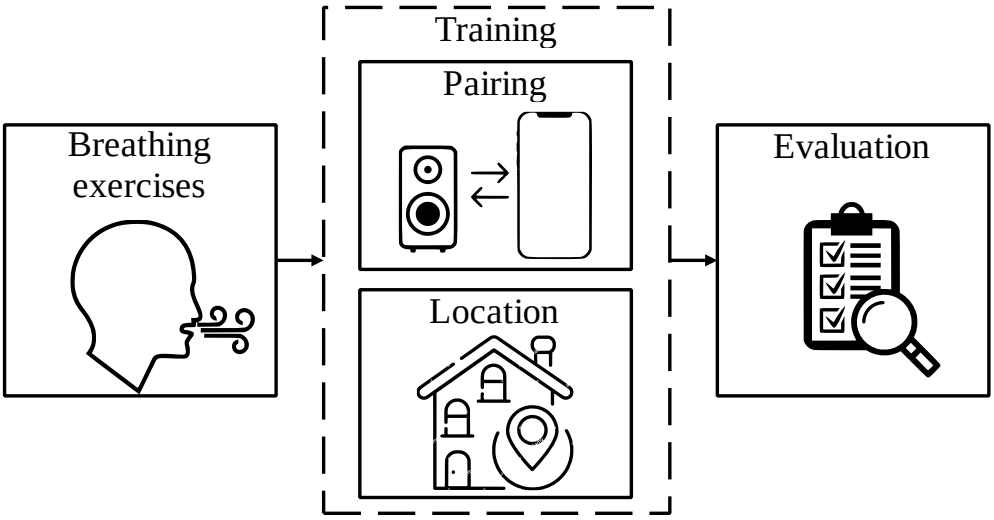

Figure 1. Stages of memory rehabilitation using the method of Loci.

Design of activities

The first activity that the participant performs is a series of exercises to improve breathing, allowing greater oxygenation of the brain, for better concentration. This makes it easier to fixate and remember the stimuli that are presented to you. As rehabilitation progresses, the patient should include mental visualizations of pleasant items or memories. In the application, it is necessary to show a reminder and the instructions for this activity, so that the psychologist verbally directs the patient's actions and reaches concentration.

In the main training, a database of at least 20 elements is required for both exercises. Figure 2 illustrates the matching and placement exercises. In pairing, two lists of items to remember are randomly generated. The number of pairs depends on the level of difficulty required, with a maximum allowed of 10 pairs. The location presents four places in the home (kitchen, living room, bedroom, and dining room), with elements randomly located in each place. The number of items per location will depend on the level required, with a maximum of 5 items per location. Both exercises are complemented with guided imagery through the mental visualization of each element.

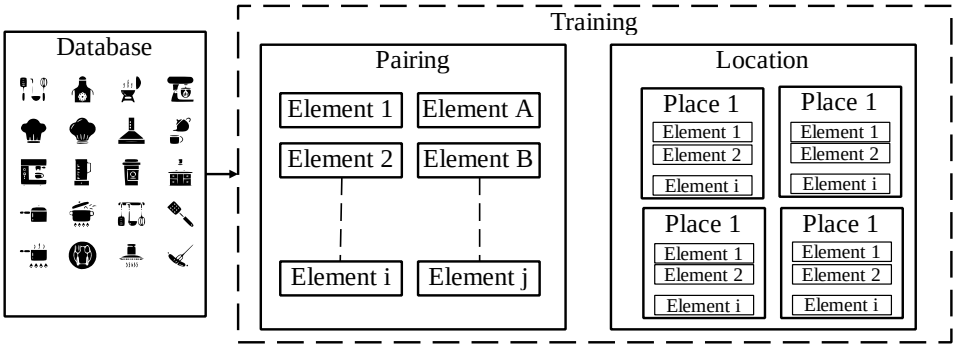

Figure 2. Characteristics of training exercises.

Evaluation design

In the evaluation stage, each training exercise is evaluated separately, the exercise being selected according to the specialist's disposition. In the case of pairing, element by element of the list is questioned, showing the selection options for the user. On the other hand, the location exercise is evaluated by consulting all the elements of each location, through a list of options for selecting the patient. For both cases, three parameters are evaluated:

- Response time: the application measures the time it takes the user to answer each question, there is no maximum waiting time.
- The hits: each correct element selected by the user is recorded as a hit cumulatively.
- The errors: each wrong selection is counted as an error and each omitted item also accumulates an error.

RESULTS

According to the requirements of this proposal, the user interface screens are designed as shown in Figure 3. Although this work is aimed at a future computer implementation, an application for mobile devices is not ruled out. That favors the proposal. A first interface can be displayed on the screens, with information for the activity of the breathing exercises. The second screen shows the main menu that allows access to the training exercises, without first entering the user name. This interface allows you to choose the level of difficulty required; by default, the matching exercise is set at five elements and the placement exercise at one element per place. The third screen shows the training for the pairing case, for a hypothetical

level 1 case. Using the “Cancel” button the user can end the exercise and with the “Continue” button to advance to the evaluation. Finally, the fourth screen illustrates the evaluation, with the question to be answered and three selection options. In this case, the continue button advances to the next evaluation question until the exam is finished.

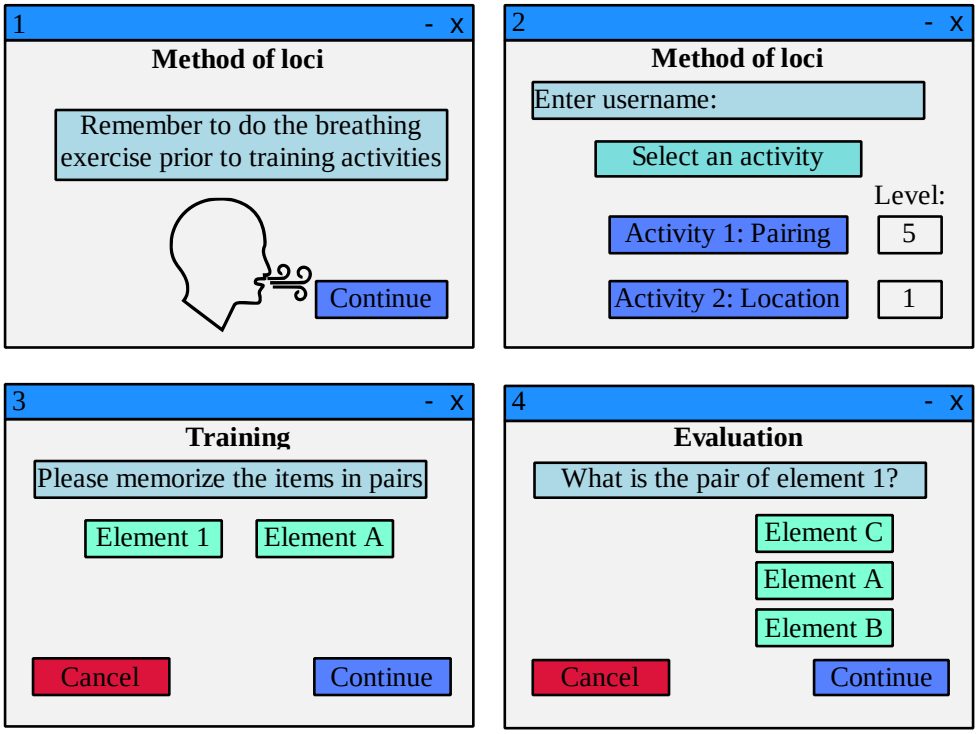

Figure 3. User interface screens for the designed application.

Regarding the evaluation of the participants, the evaluation stages have been designed to analyze the application in the future, when it is developed.

- In the first sections the participant learns to relax through breathing exercises until reaching a high level of calm. The subject will then be instructed to visualize a familiar place, concentrating on details such as colors, aromas, textures, etc.
- In week two the exercises of activity 1 of the application will be incorporated with 10 levels of difficulty, it will be carried out in 2 sessions.
- In the following 2 weeks, activity 2 will be carried out with its 4 levels of complexity, working in two weekly sessions with each participant.

DISCUSSIONS AND CONCLUSIONS

The presented design allows the future implementation of a computer application to rehabilitate memory using the method of Loci. This design is simplified and efficient, with user-friendly interfaces that the patient can use comfortably and safely. From the point of view of psychology, the application of standardized procedures allows a better diagnosis to be made and to define the particular requirements of each person.

The method of Loci allows better learning by visualizing a route of familiar locations in logical and natural order on which elements to remember are deposited using dissonance in their execution.

The types of memory that are exercised are visual, immediate, and operational sensory memory, using the visual pathway that is linked to the ability to imagine to store the information received more efficiently.

Memory training can be used for both academic instances and complex rehabilitation programs. This is why the presented design leaves open the possibility of developing desktop and mobile applications that can satisfy the needs of the individual. In addition, automating these processes allows you to define exactly certain parameters such as the response time and the number of hits in an unequivocal way. With all this information, the specialist can properly monitor the progress of the process and provide a better service.

The work presented is limited to designing a computer application to apply the Loci method, so no experiments are presented but only the designs to implement the application later. The authors of this document propose as future work the immediate implementation of this design. Thus, it can be compared with the traditional method of memory rehabilitation, allowing the results obtained to be contrasted.

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